Feature diagnosticity affects semantic representations of novel and common object categories

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INTRODUCTION

A central principle in feature-based theories of semantic memory is the differential weighting of some features over others [1-5].

Some of these features are **diagnostic** – they serve to distinguish or otherwise conspicuously differentiate one item from others [6,7].

In determining feature diagnosticity, we argue for a distinction between when a feature is available and needed, and when it is actually used.

Color is **necessary** in order to distinguish lemons and limes.

Color is **available** but not needed in order to distinguish stop signs and yield signs.

Using color as the diagnostic feature, we used a training paradigm to investigate how diagnostic features interact with semantic representations.
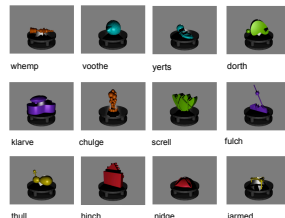
METHODS

Subjects learned one of two novel object sets over the course of four sessions:

COLOR + SHAPE:

whemp voothe yerts dorth
klarve chulge screll fulch
thull hinch nidge jarmed

SHAPE:

whemp voothe yerts dorth
klarve chulge screll fulch
thull hinch nidge jarmed

Color is necessary, shape is not sufficient.
P (object | shape) = 0.33
P (object | color) = 0.50
P (object | shape AND color) = 1.00

Color is available, shape is sufficient:
P (object | shape) = 1.00
P (object | color) = 0.50
P (object | shape AND color) = 1.00

Following training, subjects performed a number of behavioral tasks, including adjective generation and pairwise general similarity ratings:

klarve
1. purple
2. blobby
3. round
4.

klarve
chulge
1 2 3 4 5 6 7 8 9
Very dissimilar   Very similar
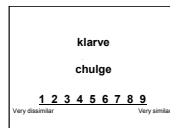
Thirty-two of these subjects (*n* = 16 for each group) performed a shape retrieval task while undergoing fMRI, answering yes/no shape questions about the objects. This task was followed by a functional color localizer.

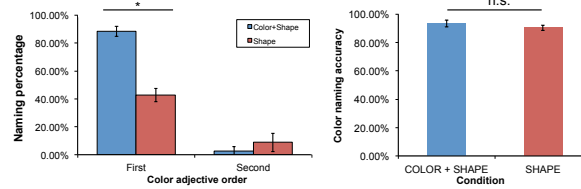If you flipped a KLARVE over, would it stand up straight?
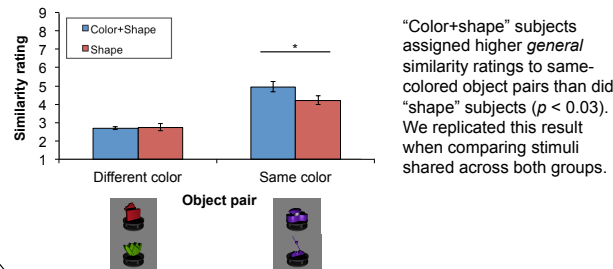
Shape retrieval task

Color perception task

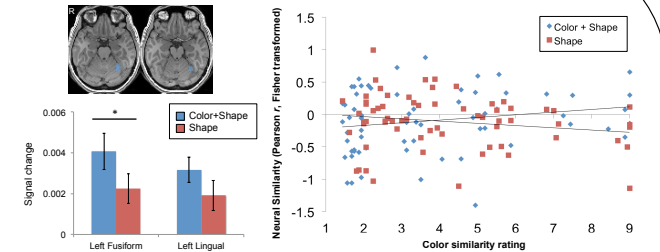*For more on the color perception task, please see Poster G101 (Persichetti).*

RESULTS: BEHAVIORAL

When listing object adjectives, "color+shape" subjects (*n* = 29) listed color first 88% of the time, whereas "shape" subjects (*n* = 34) listed color first only 45% of the time (*p* < 0.001). Notably, the groups demonstrated comparable explicit object color knowledge.

"Color+shape" subjects assigned higher *general* similarity ratings to same-colored object pairs than did "shape" subjects (*p* < 0.03). We replicated this result when comparing stimuli shared across both groups.

RESULTS: GENERALIZATION

We examined the extent to which these results generalized to common object categories via fruits and vegetables (FV, color is diagnostic) and household items (HHI, color is *not* diagnostic) through parallel behavioral and fMRI tasks.

If you flipped a CARROT over, would it stand up straight?

Like "color+shape" subjects, those subjects describing FV objects were more likely to list color first. When combining novel and common object categories, we found that prioritizing color positively correlated with left fusiform activation.
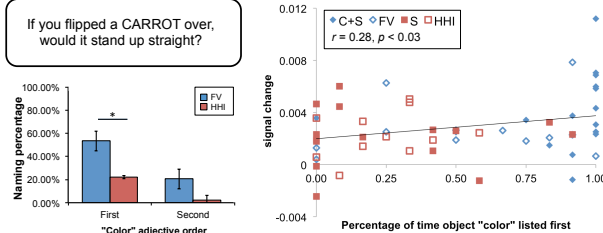
RESULTS: FMRI

Left fusiform gyrus (involved in color perception): greater activation during a *shape* retrieval task for "color+shape" subjects. Independent color similarity ratings approached significance in predicting neural similarity for "color + shape" subjects (r_s = 0.22, *p* = 0.08), which differed significantly from "shape" subjects (*Z* = 1.98, *p* < 0.05).
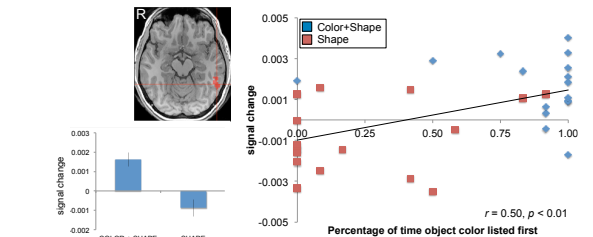
Left inferior temporal gyrus (identified through exploratory analyses): showed an interaction of training condition and task. Prioritizing color positively correlated with brain activity.

DISCUSSION

- Features can vary both in how well we *know* and *use* them, and this distinction taps into semantic representations.

- These results parallel previous work demonstrating differences in conceptual knowledge for blind versus sighted subjects [8].

- The neural instantiation of diagnostic features may vary along a posterior-anterior gradient in ventral temporal cortex.

- Preliminary results suggest a similar neural basis for the interaction of feature diagnosticity with representations of both novel and common object categories, supporting generalization of our findings.

REFERENCES
1. Allport D (1985) Distributed memory, modular subsystems and dysphasia. In *Current Perspectives in Dysphasia*, Edinburgh: Churchill Livingstone. 2. Warrington EK, McCarthy RA (1987) *Brain: A Journal of Neurology* 110: 1273-1296. 3. Tyler LK, Moss HE (2001) *TICS* 5: 244-252. 4. Patterson K, Nester PJ, Rogers TT (2007) *Nat Rev Neuro* 8: 976-987. 5. Thompson-Schill SL (2003) *Neuropsychologia* 41: 280-292. 6. Gonnerman LM, Andersen ES, Devlin JT, Kempler D, Seidenberg MS (1997) *Brain Lang* 57: 254-279. 7. Devlin JT, Gonnerman LM, Andersen ES, Seidenberg MS (1998) *JOCN* 10: 77-94. 8. Connolly AC, Gleitman LR, Thompson-Schill SL (2007) *PNAS* 104: 8241-8246.

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